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COSUMNES RIVER DIVISION CENTRAL VALLEY
PROJECT - WATER QUALITY CONTROL STUDY,
COSUMNES RIVER BASIN, CALIFORNIA

Federal Water Pollution Control Administration
San Francisco, California

July 1967

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WATER QUALITY CONTROL STUDY

COSUMNES RIVER BASIN

CALIFORNIA

ABSTRACT

A study of the Cosumnes River Basin shows that reservoir storage for the purpose of regulating stream flow for water quality control is not needed. Water quality detriments of the proposed Cosumnes River Division can be mitigated by operation of this and other units of the Bureau of Reclamation's Central Valley Project to maintain appropriate water quality standards in the Sacramento - San Joaquin Delta.

U. S. DEPARTMENT OF THE INTERIOR

Federal Water Pollution Control Administration
Southwest Region
San Francisco, California

July 1967

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I. INTRODUCTION

AUTHORITY

The study described in this report was made in accordance with the provisions of the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et seq.) and Executive Order 11288, dated July 2, 1966.

PURPOSE AND SCOPE

The purpose of this report is to present an evaluation of (1) the potential impact on water quality of the proposed Cosumnes River Division, Central Valley Project, Bureau of Reclamation, and (2) the need for and the value of storage for the regulation of stream flow for water quality control in the Cosumnes River Basin, California.

The study area is located about 30 miles southeast of Sacramento, California between the Mokelumne River to the south and the American River Basin to the north (see Figure 1). The study is limited to an analysis of data available from County, State and Federal agencies. The time horizon considered, 1970 to 2020, conforms with that used by the Bureau of Reclamation in the development of the project.

ACKNOWLEDGEMENT

The cooperation and assistance of the following Federal and State agencies added significantly to the value of this study:

Bureau of Reclamation, Region 2
Department of the Interior
Sacramento, California

Fish and Wildlife Service
Bureau of Sport Fisheries and Wildlife
Department of the Interior
Sacramento, California

Bureau of Outdoor Recreation
Department of the Interior
San Francisco, California

Central Valley Regional Water Quality Control Board
State of California
Sacramento, California

II. SUMMARY OF FINDINGS AND CONCLUSIONS

FINDINGS

1. The Bureau of Reclamation's Central Valley Project consists of six dams and reservoirs in the Cosumnes River Basin. Three dams and reservoirs are proposed in the initial phase of the project.
2. The watersheds of the proposed reservoirs are located in the lower elevations of the Sierra Nevada Mountains within El Dorado, Amador, San Joaquin and Sacramento Counties of California.
3. Proposed project purposes include storage of municipal, industrial and agricultural water, flood control, hydroelectric power production, fishery and wildlife mitigation and enhancement, recreation developments, and water quality control. Water for the irrigation of 40,000 acres of land within the Cosumnes River Basin will be the main conservation feature. The ultimate development of the project will increase the annual yield of the Central Valley Project by 155,000 acre-feet. Of this total, 125,000 acre-feet will be used for irrigation and the remainder for municipal and industrial water supply.
4. The channels of the lower Cosumnes River and tributaries are wide and porous. During the summer months there is essentially no natural flow in these lower reaches for extended periods because of low runoff, high percolation rates into creek beds and extensive diversions from the river.
5. Cosumnes River water is of exceptionally good quality containing low total dissolved solids. It is suitable for all municipal, industrial and agricultural uses.
6. The economy of the area is predominantly agricultural in character. Existing agricultural water supplies are derived by diversions from the Cosumnes River and from the local ground water basin. Municipal and industrial water supplies are derived mainly from ground water and import from the Mokelumne River.
7. Cold and warm water fisheries exist in the upper main stem of the Cosumnes River. The U. S. Bureau of Sport Fisheries and Wildlife and the California Department of Fish and Game plan to maintain the fisheries on the main stem of the river and to develop new fisheries in the proposed reservoirs.
8. Municipal waste disposal of treated effluents is accomplished by land application, subsurface percolation or discharge to the Cosumnes River or tributaries. Pollution problems at present are minimal.

CONCLUSION

1. The study area population will increase from the present 16,000 (1965) to about 100,000 by 2020. Residential-commercial expansion from the city of Sacramento, and growth in the trade and service facilities are projected to occur in the lower basin.
2. Discharges of treated municipal and industrial wastes in the river are expected to contain about 600 pounds of BOD₅ per day in 1970 and about 3000 pounds in 2020.
3. The nitrogen content of municipal treatment plant effluent and agricultural drainage will increase from about 260,000 pounds per year in 1970 to about 726,000 pounds per year by 2020. Phosphorus in wastes from municipal and agricultural sources will increase from about 53,000 to 182,000 pounds per year in the corresponding period.
4. Land application will continue to be the most practical method for the disposal of treated municipal and industrial waste in the sparsely settled Upper Basin. In the Middle and Lower Basins, waste effluent will be discharged to the Cosumnes River or its tributaries.
5. Nitrogen and phosphorus loadings into the Cosumnes River will create water quality problems before the year 2000. The dilution of the nutrients to acceptable standards and the use of advanced treatment methods on the M&I wastes are possible solutions to the problem. The releases for the fishery will assist in solving this problem, but by the year 2000, additional measures other than employing project water for dilution will be needed. Alternative measures employing advanced treatment methods should be used. Removal of nitrogen and phosphorus up to 80 percent and 90 percent, respectively, are within present technical feasibility.
6. Predicted upon advanced treatment methods and with the releases of water for the fishery, storage in project reservoirs for stream flow regulation for water quality control in the Cosumnes River or tributaries will not be needed.
7. The project will have detrimental effects on water quality not only in the river but also in the Sacramento-San Joaquin Delta because of local consumptive use of water and the generation of additional wastes. The proposed fishery releases would contribute to the mitigation of these detriments in the river and the Delta and these releases supplemented by project return flows, would contribute to the needs for salinity repulsion in the Delta. However, satisfactory conditions in the Delta can not be achieved without controlling Delta outflow at the level

necessary to repulse salinity, and transport residual wastes, (conservative wastes which cannot be removed economically by treatment) so as to maintain a quality of water which will support the many and intensive existing beneficial uses. It is necessary, therefore, that the Bureau of Reclamation operate the Cosumnes River project, in conjunction with all other units of the Central Valley project and in coordination with other projects, in a manner which will avoid excessive depletion of Delta outflow and deterioration of water quality. Water quality levels to be maintained in the Delta will be established in accordance with the Federal Water Quality Act of 1965 (PL 89-234). These water quality standards, will provide the necessary operating criteria for the Central Valley Project.

8. Water quality will be affected by storage in project reservoirs. Observations in existing reservoirs on the adjacent Mokelumne River and the American River basins have shown that stratification occurs seasonally. For this reason, multi-level outlets should be considered for the Nashville Reservoir to permit the withdrawal of the best quality water available at time of release.

III. PROJECT DESCRIPTION

The proposed Cosumnes River Division of the Central Valley Project, consists of six multi-purpose dams and reservoirs to provide for irrigation, municipal and industrial water supplies, flood control protection, power benefits, recreational developments, fish and wildlife enhancement and water quality control. The initial phase of the project consists of Nashville, Aukum, and Pi-Pi Reservoirs and the ultimate phase is composed of Irish Hill, Capps Crossing and Ponderosa Reservoirs. These facilities are supported by five small diversion and regulating dams, pumping plants, canals, tunnels, and conduits.

The locations of dams and reservoirs and supporting facilities are shown on Figure 1. Pertinent information on the proposed dams and reservoirs are shown on Table 1. The several reservoirs located on the main stem of the Cosumnes River will store runoff within the upstream watershed. However, Irish Hill Reservoir will collect not only the limited runoff from Dry Creek but will also receive water transferred from Nashville and Ponderosa. Ponderosa Reservoir on Jackson Creek will store water imported from the Mokelumne River for use in the upper Sutter Creek area and for diversion into Irish Hill Reservoir.

In total, the initial and ultimate phases of the project will have an annual yield of about 155,000 acre-feet to serve approximately 40,000 acres of irrigable land, and to provide M&I supplies to the proposed service areas. About 125,000 acre-feet per year will be used for agricultural purposes and the remainder for M&I purposes. Surplus water will not be available for export out of the basin after the completion of the ultimate phase of development. Except for spills, the project will provide for the complete control of the water resources of the basin.

TABLE 1

MAJOR FEATURES OF COSUMES RIVER DIVISION
CENTRAL VALLEY PROJECT
BUREAU OF RECLAMATION

Structure	Type	Dam Height (feet)	Reservoir Capacity (acre-feet)	Purpose
Nashville Dam	Earthfill	426	900,000	P, I, F, M & I, D, FC
Nashville Regulating Dam	Concrete	52	1,250	F
Aukum Dam	Earthfill	197	120,000	I, F, M & I
Irish Hill Dam	Earthfill	185	100,000	I, F, M & I, FC
Ione Diversion Dam	Concrete	90	1,950	D, I, M & I
Sutter Creek Diversion Dam	Concrete	20	10	D
Pi-Pi Dam	Earthfill	257	70,000	I, F, M & I, D
Dew Drop Regulating Dam	Earthfill	70	208	I, M & I
Capps Crossing Dam	Earthfill	191	25,000	I, M & I, D
Steeley Fork Diversion Dam	Concrete	20	60	D
Ponderosa Dam	Earthfill	164	6,000	I, M & I

a/ Include 20,000 KW Power Plant

b/ P = Power

I = Irrigation

F = Fishery, Reservoir and/or downstream

D = Diversion

M&I = Municipal and Industrial Water Supply

FC = Flood Control

IV. STUDY AREA DESCRIPTION

LOCATION

The drainage basin of the Cosumnes River includes the watersheds of the main stem and the three major tributaries, Laguna Creek, Deer Creek and Dry Creek. The entire basin drains about 1100 square miles in the lower slopes and foothills of the Sierra Nevada Mountains, southeast of Sacramento, California.

The study area of the Cosumnes River Division, Central Valley Project lies within the river basin and is bounded by the American River Basin on the north, the Mokelumne River on the south, the Sierra Nevada on the east, and the proposed Folsom South Canal on the west. The lower reaches of the Cosumnes River Basin west of the Folsom South Canal to the confluence with the Mokelumne River is within an area called the Delta Uplands. This triangular segment is outside of the Bureau's Cosumnes River Division but is within the service area of the Auburn-Folsom South Canal Unit, Central Valley Project. For the purpose of this study, the Delta Uplands area will be included for waste load evaluation purposes, since it is within the drainage basin and is a potential source of waste discharge to the Cosumnes. Several small segments of the drainage basin that have not been included within the Bureau's proposed service area are included in this study area for waste evaluation purposes. The entire study area, reaching into Sacramento, El Dorado, San Joaquin and Amador Counties, is shown on Figure 1.

Below the confluence with the Mokelumne River lies the Sacramento-San Joaquin Delta, a maze of inter-connected tidal channels and sloughs. This area is considered outside the scope of this study for water quality evaluation purposes since the Delta is under tidal influence and is directly affected by major inflows from the Sacramento River and the San Joaquin River, the depletion of water by export to Central and Southern California, and tidal effects. The influence of inflow from the Cosumnes is small in the Delta since the runoff comprises less than 2 percent of the annual discharge into the Delta.

Elevation of the watershed varies from about 7 feet above sea level in the Delta Uplands to over 7,000 feet in the highlands of the Sierra Nevada. Pine trees are native to the highlands and the area is covered with light to deep forests. The foothills of the upper drainage basin is characterized by a rolling terrain supporting woodland, grass and scrub brush. Vegetation near the creek beds consists of willow, cottonwood and wild blackberry. Grazing land occupies a large part of this area and consists of wild oats and barley. Dry land farming forms a major part of the agriculture in the foothill area. The lower area of the basin is devoted in large part to irrigated agriculture and is characterized by the flatlands of the Delta Uplands, which is within the rich farm belt of the Central Valley.

CLIMATE

The climate of the Cosumnes River Basin is typical of the Central Valley of California with cool winters and warm and dry summers. The mountainous area of the upper basin tends to be cooler than the lowlands with the mean annual temperature varying from about 60°F in the lower basin to about 55°F in the cooler reaches of the highlands. The mean daily maximum in the lower basin is about 76°F during the summer months while the area in the Sierra Nevada is cooler (mean daily maximum, 72°F).

Rainfall varies from about 14 inches in the lower elevations to about 48 inches in the high mountainous regions. About 70 percent of the precipitation occurs in the months of December through March. The average annual snowfall ranges from near zero in the lowlands to about 3 feet in the higher elevations of the Sierra Nevada.

V. WATER RESOURCES OF THE STUDY AREA

SURFACE WATER

Stream runoff is largely the result of seasonal rainfall on the watershed and spring snow-melt. Because the higher watershed area is small and at relatively lower elevations of the Sierra Nevada, the snow pack is almost completely exhausted by the end of spring. As only about 15 percent of the watershed lies above the 5,000 feet elevation, peak flows in the river usually occur in the early spring months. During the dry summer months, flows in the upper reaches of the watershed decrease to a few cubic feet per second. These small dry weather flows are usually entirely diverted for irrigation or lost through the porous stream bed of the lower reaches of the Cosumnes. As a result, the lower Cosumnes River is often without flowing water from July through November. Historical records (1942-1965) have shown that no-flow conditions existed for more than 120 consecutive days annually during more than 25 percent of the years of record. In 1955, no flow existed for more than 150 days consecutively during the summer.

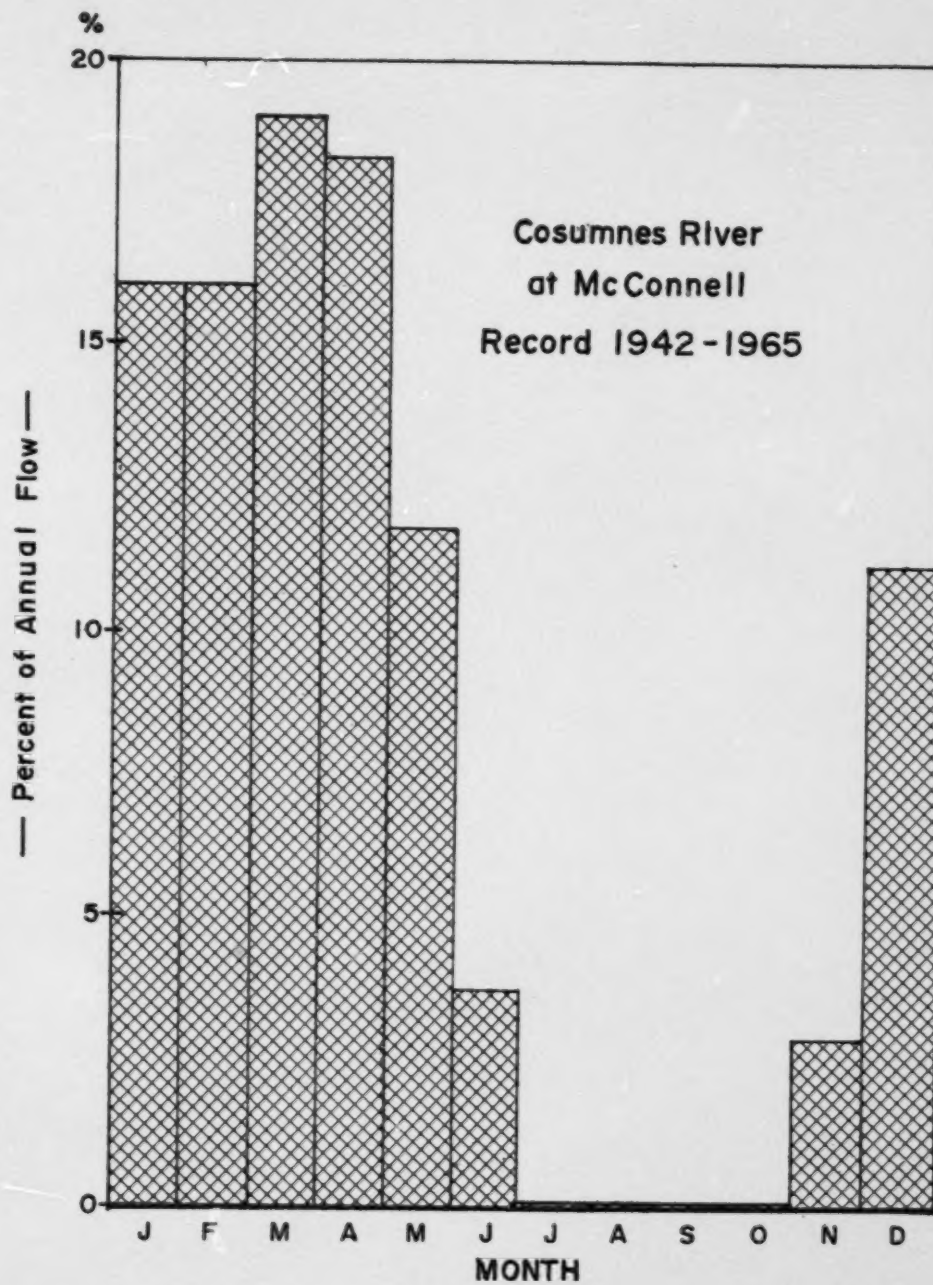
The runoff of the Cosumnes River varies widely from season to season. The mean annual runoff at the McConnell gaging station located near Galt, is 326,000 acre-feet [1]. A peak discharge at this gaging station of about 42,000 cfs was recorded in December 1955. A major portion of the runoff occurs in the wet months as illustrated in Figure 2, showing the monthly distribution of annual runoff. Mean daily flow frequency of the river for the period of record (1942-1955) at the McConnell gaging station [2] is shown in Figure 3. About 20 percent of the time, the flow of the Cosumnes is less than 20 cfs at this gaging station.

At the proposed Ione and Sutter Creek Diversion Dams, the annual flows are estimated to average about 30,000 acre-feet on Dry Creek, and 26,400 acre-feet on Sutter Creek [3]. The watershed of Deer Creek, west of the main stem of the Cosumnes, yields a recorded average annual flow of about 15,000 acre-feet [3]. Runoff from these tributaries of the Cosumnes River is mainly from rainfall rather than snowmelt and therefore, their annual and monthly flows are even more variable than on the main stem. Summer flow on these creeks is absent with dry creek beds commonly experienced a large part of the dry season.

GROUND WATER

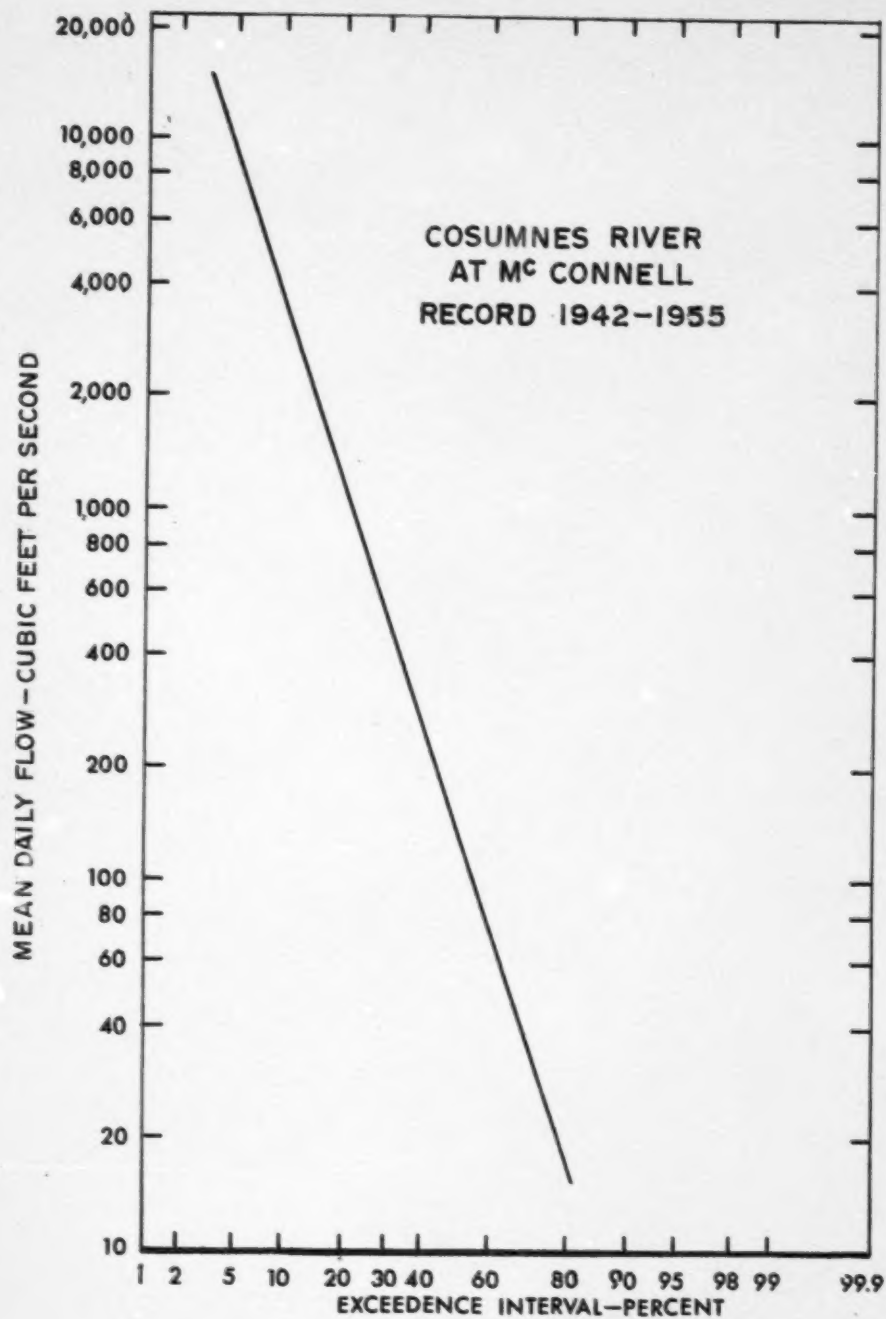
Ground water in the study area is grouped into three principal areas of similar geologic and hydrologic features. These are designated the Upper, Middle, and Lower Basins (see Figure 1).

The oldest geological formations in the Cosumnes River Division are of the pre-Cretaceous age which form the core of the Sierra Nevada Mountains. In



**MONTHLY DISTRIBUTION
OF ANNUAL FLOW
— COSUMNES RIVER —**

DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTHWEST REGION SAN FRANCISCO, CALIFORNIA



COSUMNES RIVER BASIN

MEAN DAILY FLOW FREQUENCY

DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTHWEST REGION SAN FRANCISCO, CALIFORNIA

the upper area, the western points of the mountains are composed of meta-sedimentary and igneous type rocks. Because these rocks are essentially impermeable, ground water table does not exist. Since wells and springs in the region obtain their water from joints sets and formation contacts, yields are very low and wells often go dry in the summer. Ground water in these areas is not dependable throughout the year.

In the Middle Basin the oldest rocks are also of the pre-Cretaceous age core of the Sierra Nevada. These older rocks are overlain by Tertiary and Quaternary age formations which are the principal water bearing stratigraphic units. Safe ground water yield under present conditions of land development, is less than 10,000 acre-feet annually [3].

In the Lower Basin, the principal water bearing strata are in the recent Alluvium and the Victor formation of the Quaternary age and the Laguna formation of the Tertiary age. The ground water in this area is pumped extensively by large communities and by agriculturists. The Bureau of Reclamation in their study of their Folsom South Canal Unit, estimated the total safe yield of the Delta Uplands in both the American and the Cosumnes River Basins to be about 142,000 acre-feet per year. About 50,000 acre-feet of this yield is available within the Lower Cosumnes River Basin. The ground water of this lower basin will be fully utilized in the development of the Folsom South Unit of the Central Valley Project.

SURFACE AND GROUND WATER QUALITY

Records of surface water analysis as reported by the California Department of Water Resources [4] indicate the water is the bicarbonate type, soft and of excellent mineral quality for all purposes. Analysis of water samples taken in the upper and lower reaches of the Cosumnes indicate very little change in quality. Coliform counts indicate bacterial contamination is slight. Dissolved oxygen levels remain high at all locations. A summary of selected water quality parameter of samples collected over a twelve year period (1952-1964) at the Michigan Bar Gaging Station is presented in Table 2.

According to the U. S. Geological Service Hydrological Atlas, HA-235 [5], the annual median temperature of the surface water is between 55-60°F in the lower reaches of the Cosumnes and 50-54°F in the higher elevations. Suspended sediment records of the U. S. Geological Survey on the Cosumnes River [6] show that a total load of 335,000 tons was discharged during the 1962-1963 water year. The Bureau of Reclamation has selected for design purposes a mean annual sediment load of 0.15 to 0.20 acre-feet per square mile over the 100 year life of the project reservoirs.

TABLE 2
SURFACE WATER QUALITY
COSUMNES RIVER BASIN ^{a/}

Constituents ^{b/}	: : Maximum of Record	: : Minimum of Record
Calcium	13	4
Magnesium	6.3	0.5
Sodium	5.6	1.8
Potassium	1.8	0.5
Carbonate (CO ₃)	3	0
Bicarbonate (HCO ₃)	77	36
Sulfate	12	0.0
Chloride	5.2	0.0
Nitrate	1.2	0.0
Fluoride	0.3	0.0
Boron	0.25	0.00
Silica (SiO ₂)	21	15
Total Dissolved Solids	98	31
Total Hardness (as CaCO ₃)	58	18
Specific Conductance (Micromho at 25°C)	139	42.2
ph	8.3	6.8
Temperature (°F)	86	35
Dissolved Oxygen	12.9	6.3
Percent Saturation	132	72
Turbidity (JCU)	300	0.2
Coliform (MPN per 100 ml)	2400	0.06

^{a/} Data from the California Department of Water Resources [4]
Period of record, May 1952 - Sept. 1964
Cosumnes River at Michigan Bar Gage (see Figure 1 for location)

^{b/} Concentration expressed in milligram per liter, unless noted otherwise.

Ground water in the lower basin is excellent in quality and is also the bicarbonate type, soft to moderately hard, and suitable for most uses. Inferior quality of water has been reported from some wells but these have been the exception rather than general for the area. Total dissolved solids, chlorides, nitrates, and boron are relatively low but slightly higher than the surface water. A summary of selected water quality parameters collected 7 during the period between 1957-1962 is shown in Table 3.

OTHER POTENTIAL SOURCES OF WATER

The Bureau of Reclamation is initiating design of the Folsom South Canal, an authorized project of the Central Valley Project, for conveyance of American River water from Lake Natoma to service areas in the lower American and Cosumnes River basins and portion of the San Joaquin River basin. Annual diversion of about 450,000 acre-feet is planned but the Canal will be designed for extension of the service area further southward into southern San Joaquin Valley. This latter phase of the Central Valley Project (East Side Canal Unit) is under study presently by the Bureau of Reclamation and present plans envisage an ultimate export of 4,000,000 acre-feet annually to the south. Most of this water will be derived from developments in the north coastal area of California. Another potential source of water to the study area is by diversion from the Mokelumne River basin. Presently about 15,000 acre-feet is available for diversion annually to the Sutter Creek area under existing water rights. It is probable that this would be the maximum permitted as the water resource of the Mokelumne River basin is nearly fully developed with a minimum available for export.

TABLE 3

GROUND WATER QUALITY
COSUMES RIVER BASIN ^{a/}

Period of Observation	Criteria	Ca : mg/l	Mg : mg/l	Na : mg/l	HCO ₃ : mg/l	NO ₃ : mg/l	B : mg/l	CL : mg/l	SiO ₂ : mg/l	Total Dissolved Solids : mg/l	Total Hardness : as CaCO ₃ : mg/l
1957	Max.	22	12	21	166	6.2	0.05	15	51	188	106
	Min.	17	10	20	122	0.0	0.02	7.1	38	182	84
1959	Max.	21	13	22	174	6.9	0.10	15	79	207	105
	Min.	31	4.2	11	93	0.5	0.00	6.8	50	172	55
1962	Max.	28	15	22	149	11	0.1	17	66	215	131
	Min.	8	4	8.8	49	0	0.0	3.5	29	131	39

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^{a/} Source: California Department of Water Resources [7]

VI. THE ECONOMY

The economy of the study area was evaluated to permit projection of population growths for estimating water supply needs and waste loads.

PAST AND PRESENT

The Cosumnes River basin is an historical gold-mining area of the middle 1800's. The economy of the placer mining operation of the gold rush days subsided with the depletion of the more easily mined deposits of the Mother Lode Country. Economic activity declined following the gold rush until about 1920, after which an upturn followed slowly with small population growths occurring at fluctuating rates. The study area has a 1965 population of about 16,000, mostly concentrated in the rural areas of the lower basin. Galt (1965 pop. 2,000) and Jackson (1965 pop. 2,000) are the two largest towns. The remainder of the population is located mainly in small crossroads or remote communities of a few hundred inhabitants and on farms. The entire basin is predominantly rural in character with agriculture the basic enterprise. In the Upper and Middle Basins, cattle raising and dry land farming are the main source of agricultural revenue due to the topography and the limited availability of dependable water for irrigation. Moreover, since the area is relatively isolated and remote from good transportation and market outlets, irrigation developments have been limited. However, more recently, irrigation has been practiced on flat lands near the river of the Middle Basin where water is more readily available from surface diversions.

In the Lower Basin, agriculture is an important part of the economy. Water is more readily available and irrigated agriculture has developed extensively. Near the Delta, the agricultural products of the area are an important cash revenue. Field crops and dairy farming form the more important agricultural activities. The proximity to the state capital, Sacramento, provided natural outlets for agricultural products as well as access to good transportation systems. Agricultural statistics of the study area is shown in Table 4. As noted, livestock and livestock products (mainly dairy) form the largest portion of the farm output value.

TABLE 4
AGRICULTURAL STATISTICS
COSUMNES RIVER BASIN ^{a/}
1959

Number of Farms	560
Cropland Harvested (Acres)	25,000
Value of All Crops Sold	\$ 2,978,000
Value of Livestock & Allied Products Sold	\$ 3,022,000
Total Farm Products Sold	\$ 6,000,000

^{a/} Source: U. S. Bureau of Census, 1959 [8]

Mineral resources of the study area are extensive. As noted previously, the area was a leading gold producing area but gold mining operations have declined during the past 50 years. However, extraction of non-metallic minerals has been a significant part of the economy with mining of clay in the vicinity of Ione an important operation. These clay deposits can be used to make high quality organic refractory products. Lignite deposits are found south of Ione and have been developed to supply all the montan used in the United States. This is an important ingredient in electrical insulation, shoe and floor wax, ink, and carbon paper. Fertilizer is an important by-product of the extraction process.

A quarry for building stone has been opened near Volcano, wherein a rhyolite-tuff is sold as ornamental building stone. Copper, lead, manganese, silver and limestone are found and production may be encouraged by increasing demands and advancement in extraction and refining technology.

The lumber industry of the area constitutes an important segment of the present economy. The study area contains over 2.5 billion board feet of good quality timber and supports three large sawmills and one plywood plant. The most important species of timber is ponderosa pine but white fir and cedar are present in significant volume.

Manufacturing has not been a strong part of the economy but includes a plant for making wood molding, frames and box shooks, a refractory clay product plant and a plant for extracting montan from lignite. A large portion of the manufacturing establishment is associated with processing of the natural resources of the area.

FUTURE

The future growth and development of the study area are expected to be residential-commercial and agriculture, as stimulated by the newly irrigated lands. However, the population growth associated with agriculture will not be as great as the residential overflow from the Sacramento metropolis into the lower basin. In this area, the residential growth would eventually supplant some of the agricultural developments which would be encouraged by the Folsom South Canal and the Cosumnes River Division projects.

Industrial growth is not expected to be significant as industries are expected to continue to concentrate in locations closer to Sacramento where excellent access is available to a deep water channel and good air and rail transportation systems. The existing small industries of the study area, associated with wood products and other local natural resources, are expected to retain their present stage of development but extensive expansion is not foreseen. A nuclear power plant (800 MW) is under consideration by the Sacramento Municipal Utility District for construction near Clay.

In the Upper Basin, the economy is not expected to vary from the present rural pattern. The proposed irrigation development will encourage the economic growth but the agricultural population growth will not be significant. With the development of recreational areas in and around the proposed reservoirs and the concurrent roads improvements, the area will experience some growth in the recreation oriented services and associated residential-commercial developments. In a report by the National Park Service /9/ estimated visitations during the first year after construction of the initial phase would be approximately 1,206,000 recreation days. With the full development of the ultimate phase of the project, a total of 4,017,000 visitor days would be expected annually. The proximity of the area to Sacramento makes the recreational developments attractive to a large urban population. In addition, in recent years there has been a large influx of retired people to the Mother Lode Country and this could have an impact on the population growth.

The distribution of the labor force in the study area is projected in Table 5 for the terminal study year (2020) and is compared with that in 1960 /10/.

TABLE 5

LABOR FORCE DISTRIBUTION
COSUMNES RIVER BASIN

	a/ 1960		2020	
	LABOR FORCE	PERCENT	LABOR FORCE	PERCENT
Agriculture, Forestry & Fishery	892	19.6	2800	8
Mining	40	0.9	350	0.1
Construction	279	6.2	1750	5
Manufacturing, Total	1291	28.8	8750	25
Furniture, lumber, wood	600	13.3	5250	15
Others	691	15.5	3500	10
Services	2000	44.5	2350	61.9
Total Labor Force	4502	100	35000	100

a/ Source: U. S. Bureau of Census, 1960 /10/

The relative growth in the residential-commercial character of the area as compared to the agricultural growth is indicated by the growth in the services work force and the relatively lower agricultural work force.

For the purpose of the study, population projections were made for two waste loading points in the Middle Basin and one point in the Lower Basin. These are points where population concentrations are expected to be heavy and impact on receiving streams to be the most severe. The areas near Sloughhouse, Ione and Galt are identified as major waste discharge points for the Middle and Lower Basins (see Figure 1). In the Upper Basin, the population would be scattered and concentration of waste discharges at a primary location is not envisioned. Therefore, the population growth was grouped as single unit in the Upper Basin, but it should be recognized that this population will be widely dispersed over a large area. The population projections for the designated areas are shown in Table 6. A maximum population of about 100,000 is forecasted for the year 2020.

TABLE 6

POPULATION PROJECTIONS
COSUMNES RIVER BASIN ^{a/}

Location	1965	1970	2000	2020
<u>Lower Basin</u>				
Galt Area	6198	9367	25377	40250
<u>Middle Basin</u>				
Jackson Area	5460	6009	15019	28990
Sloughhouse Area	987	3516	9216	13350
<u>Upper Basin</u>	3502	4587	12494	17530
Total	16147	23479	62106	100120

^{a/} Sources: Office Records of Bureau of Reclamation 1967 [11] and U. S. Bureau of Census 1960 [10]. Study area lies within Sacramento, Amador, El Dorado, and San Joaquin Counties, California.

VII. WATER REQUIREMENT - MUNICIPAL, INDUSTRIAL AND AGRICULTURAL

PAST AND PRESENT WATER USES

The water resources of the Cosumnes River are relatively undeveloped, except for the small project in Jenkinson Lake (41,000 acre-feet capacity). The Bureau of Reclamation constructed this reservoir on Sly Park Creek to provide irrigation water service for an agricultural development in the adjoining American River Basin. Presently, water is diverted within the Upper Basin from old canals remaining from the gold mining operations for small agricultural and M&I needs. The total diversion by organized water service groups is very limited. In the isolated areas of the Upper Basin, diversions are made from streams or from wells located along streams, for domestic and livestock purposes. The total amount of water use in the Upper Basin is attributed almost exclusively to the 23,000 acre-feet developed annually from Jenkinson Lake for export into the American River Basin. The quantity of water used is much less than the potential development of the Upper Cosumnes Basin.

In the Middle and Lower Basins, water uses have been developed to a greater scale. Agricultural diversions from the Cosumnes River during a large part of the summer months normally keeps the river bed dry. An annual surface diversion of about 10,000 acre-feet was estimated over a twelve year (1948-1960) period of record 37. In addition, more than 25,000 acre-feet is extracted annually from the ground water basin for both M&I and agricultural purposes.

In the Jackson-Sutter Creek area, the local communities derive their water supplies mainly from imported Mokelumne River water. This diversion has been made since the early gold mining days, and has totalled about 10,000 acre-feet annually 11 at most.

Because the population of the study area is relatively sparse, the total M&I water use at present is low compared to the potential supply available. Galt (1965 pop. of 2,000) is serviced by wells and the two large towns of Jackson (1965 pop. of 2,000) and Sutter Creek (1965 pop. 1,100) are provided water by diversion from the Mokelumne River. Almost all of the many small crossroads communities derive their water from wells, local springs or creeks. The total annual M&I water use is estimated to be about 4500 acre-feet (1965) for the entire study area.

FUTURE WATER USES

Data on the M&I water requirement in the initial phase of the Cosumnes River Division were furnished by the Bureau of Reclamation. Projections were made for the remainder of the basin to include requirements for the ultimate phase and areas outside of the Cosumnes River Division but within the Cosumnes River Basin.

An ultimate per capita water consumption of 200 gallons was employed for this projection. This is a projected increase from the present 150 gpcd rate of typical communities in the study area. It is noted, the per capita daily water use in the Central Valley exceeds the state and national average. This pronounced difference results mainly from differences in climate, and the fact that relatively cheap, unmetered water is available to the area. In addition to the limited use of water meters, the high water use in the Central Valley can be partially attributed to lawn and garden watering through a long growing season in a semi-arid climate. A comparison with coastal communities in California with more temperate climates than the Central Valley shows that less extremes of seasonal urban water use are experienced. Peak monthly use in typical valley communities ranges from 2 to 5 times the minimum month, whereas coastal communities seldom exceeds 2 times the minimum.

Based on these consumption rates, a total annual municipal water use of about 17,800 acre-feet is foreseen by 2020. In addition to this municipal requirement, a large industrial water demand has been planned by the Sacramento Municipal Utility District for their nuclear plant to be located near Clay. Completion date for the 800 MW power plant is scheduled before 1973. Annual cooling water requirement is estimated to be about 75,000 acre-feet to satisfy the ultimate power plant needs. Thus, the total annual M&I requirement for the study area will be about 92,800 acre-feet by 2020.

Under the initial phase of the Cosumnes River Division, an annual agricultural demand of about 110,000 acre-feet will be developed and will be expanded to 125,000 acre-feet under the ultimate development. This will be supported by an annual ground water withdrawal of about 9,000 acre-feet and the import of 15,000 acre-feet of Mokelumne River water under existing water rights. In the Lower Basin, about 150,000 acre-feet of American River water will be available from the Folsom South Canal and this supply will be supplemented by ground water withdrawal to meet a total requirement of about 225,000 acre-feet. Thus, for the entire study area, about 373,000 acre-feet of agricultural water will be utilized annually under the ultimate plan of development.

VIII. WATER QUALITY CONTROL

PRESENT SOURCES OF POLLUTION AND WASTE WATER

Pollution of water in the Cosumnes River Basin is at present minimal. In the upstream areas, inhabitants generally dispose of domestic waste through individual septic tanks leading to percolation pits or leaching fields for final disposal. It is probable that some wastes migrate with ground water percolation to the Cosumnes River or its tributaries but the effects are insignificant outside of the immediate location of these septic tanks. Water quality sampling data indicate very slight increases in total dissolved solids occur between the upstream areas and the lower reaches of the basin, reflecting the limited agricultural and man-made developments of the area. At present, there are no significant water quality problems in the Upper Basin.

In the Middle and Lower Basins, the larger communities provide secondary treatment before disposal by land irrigation or to local creeks, but small crossroads communities with population up to 500 treat sewage through municipal or individual septic tanks and sub-surface disposal. Local problems with overflowing septic tanks and leaching field have been reported in several of these smaller communities as the watershed land is not the most favorable for percolation. In the area of Laguna Creek, Deer Creek, and Dry Creek, the effluent never reaches the Cosumnes during the dry summer months as most of the liquid is diverted for irrigation or percolates into the creek beds. Thus, the problems associated with inadequate disposal of septic tanks effluent are confined to local contamination of the drainage systems and are seldom reflected in the main river or major tributaries of the study area. During the winter months, the natural runoff has provided adequate dilution in these problem areas. Current programs by State and Local agencies have been directed toward providing secondary treatment systems for these small communities. Present problems associated with smaller communities and individual homes served by septic tanks will be corrected in the near future under guidance of Local and State regulatory agencies. In general, the pollution problem of the study area is minimal.

A summary of present major waste sources of the study area is shown on Table 7.

TABLE 7

PRESENT WASTE WATER SOURCES
COSUMES RIVER BASIN

Community ^{a/}	Population (1960)	Waste	Treatment	Effluent Discharge
Galt	1800	Domestic	Sedimentation and Stabilization Ponds	Dead Man's Gulch leading to the Cosumnes
Sego Milk Products Galt	--	Dairy	"	"
Elk Grove	1200	Domestic	"	Laguna Creek and Land
Gibson Wine Co. Elk Grove	--	Winery	Lagoons	Laguna Creek
Compton Packinghouse Elk Grove	--	Abattoir	Lagoons	Land
Sutter Creek	1161	Domestic	Sedimentation	Sutter Creek and Land
Jackson	1852	Domestic	Sedimentation	Jackson Creek
Ione	1118	Domestic	Sedimentation and Stabilization Ponds	Sutter Creek
Preston School of Industry, Ione	900	Domestic	Sedimentation	Land

^{a/} Source: U. S. Department of Health, Education & Welfare [12] and Office Records
Central Valley Regional Water Quality Control Board, Sacramento, California,
1967 [13].

FUTURE SOURCES OF POLLUTION AND WASTE WATER

The future growth and development of areas in and adjacent to the Cosumnes River Basin are expected to be residential-commercial and agricultural. Waste load in the future will, therefore, be domestic and agricultural in nature and will probably not include significant quantities of industrial waste. Industrial growth is expected to continue to concentrate in the metropolitan Sacramento area rather than in the Cosumnes Basin.

For the purpose of determining the impact of waste loads in this study, the Cosumnes River Basin was divided into three waste loading areas (see Figure 1), along lines similar to the geological and population projection areas previously discussed. The area designated the Upper Basin is composed of the upland region above Nashville Dam and the extreme upper watersheds of Dry Creek, Sutter Creek and Jackson Creek. The Upper Basin has relatively few inhabitants at the present and its future growth would be dependent on development of adequate transportation routes to this relatively remote area of the Sierra Nevada and the attractions of these remote areas for recreation.

The Middle Basin is composed of areas within the Bureau's Cosumnes River Division bordering westward to the proposed Folsom South Canal. Included in this area are the middle watersheds of Laguna Creek, Dry Creek, and Deer Creek and all of the foothill land of the study area. Rapid growth is predicted for the area around Jackson, the county seat.

The Lower Basin is composed of a triangular section of the Delta Uplands, west from the Folsom South Canal to the confluence of the Cosumnes with the Mokelumne River. This lower area is expected to develop much more rapidly than the remainder of the study area since future developments will be affected by and follow the expansion of Sacramento, the State capital.

The most critical waste loading conditions will occur if the wastes were discharged at a few key points since large wastes discharges will produce the most serious pollution problems. In the Upper Basin, the inhabitants will be widely dispersed and major discharge points are not envisaged. Therefore, major waste point loadings in the Upper Basin will not be a problem. However, for the Middle and Lower Basins, the most critical waste loading conditions will be the result of discharges at three critical points. Wastes generated on the main stem of the Cosumnes River at the northern sector of the Middle Basin were assumed to be collected, treated, and discharged near Sloughhouse, a point at River Mile 27.6. In the southern part of the Middle Basin, all wastes from Jackson, Sutter Creek, Amador City, Ione and future developments were assumed to be collected, treated, and discharged at the confluence of Dry Creek and Jackson Creek, thence flowing into the Cosumnes at about River Mile 0.5. In the Lower Basin,

wastes were assumed to be collected for treatment and discharged near Galt at about River Mile 5.0. It is recognized that effluent will be discharged from future developments scattered along the river banks but impacts on the river will be insignificant compared to the three designated major waste points.

Organic waste loads from the major waste points are shown on Table 8.

TABLE 8
ORGANIC LOADING
COSUMNES RIVER BASIN

	BOD ₅ (lbs/day) ^{a/}		
	1970	2000	2020
Upper Basin	112	356	519
Sloughhouse (River Mile 27.5)	85	263	400
Galt (River Mile 5.0)	227	724	1210
Jackson/Sutter Creek/ Ione (Enters Cosumnes at River Mile 0.5)	162	428	868
Total	586	1771	2997

^{a/} BOD₅ Load based on 85 percent removal in secondary treatment facilities.

In the Upper Basin the daily organic load will increase from 112 pounds of BOD₅ in 1970 to 519 pounds by the year 2020. A treatment efficiency of 85 percent was assumed throughout the period of study. This removal is considered conservative for sewage treatment facilities but allowance was made for uncontrolled organic runoff from surface drainage of the basin which will escape treatment. In the Middle and Lower Basins, the daily organic waste load is expected to increase from about 475 pounds of BOD₅ in 1970 to approximately 2500 pounds in 2020. A large part of this organic load will be concentrated near Galt where the major population growth will be centered.

The nitrogen and phosphorus loadings in the Middle and Lower Basins are shown on Table 9. The loadings were determined from the flows of municipal wastes and agricultural surface and sub-surface returns. The municipal loadings were predicated on factors referenced by Weinberger [14] and the agricultural waste from surface and sub-surface return waters were based on studies by the Federal Water Pollution Control Administration [15]. As shown in Table 9, the agricultural wastes contribute a significant proportion of the nutrient load to the basin.

TABLE 9
NITROGEN AND PHOSPHORUS LOADING
COSUMNES RIVER BASIN ^{a/}
(Pounds/Year)

Location	:	Nitrogen			:	Phosphorus		
	:	1970	2000	2020	:	1970	2000	2020
	:				:			
<u>Municipal & Industrial</u>								
Sloughhouse, #/yr.		19,345	50,370	73,000		6,935	17,520	25,550
Galt, #/yr.		51,100	138,335	220,046		18,615	48,180	77,380
Jackson/Sutter Creek Ione, #/yr.		32,850	82,125	194,545		11,680	28,835	55,480
<u>Agricultural</u> , #/yr.		157,392	183,389	238,333		15,739	18,339	23,833
<u>Total</u> , #/yr.		260,687	454,219	725,924		52,969	112,874	182,243

^{a/} Loading from sewage effluent of secondary treatment plant and agricultural surface and sub-surface return wastes.

The total dissolved solids (TDS) loadings in the estuary portion of the Cosumnes (River Mile 0 to 5.0) are shown on Table 10.

TABLE 10
TOTAL DISSOLVED SOLIDS LOAD
COSUMNES RIVER BASIN

Source	: 1970	: 2000	: 2020
M&I Wastes, #/year	3,285,000	16,790,000	31,390,000
Agricultural Wastes, #/year	28,403,000	32,339,000	40,220,000
Total, #/year	31,688,000	49,129,000	71,610,000

This TDS load reflects solids carried by municipal wastes, and by agricultural surface and sub-surface drainage. A major industrial waste included in the TDS loads is expected from the cooling water of the nuclear power plant to be constructed near Clay. Although cooling water will be recycled through towers for reuse, waste flow of about 5 cfs will be discharged into cooling ponds and will overflow into Laguna Creek. This plant is scheduled for completion before 1973.

WATER QUALITY OBJECTIVES

The primary objectives for water quality control are to maintain the quality of the Cosumnes River water for irrigation and M&I water supply, fish and wildlife maintenance and enhancement, and recreation and aesthetic enjoyment of the natural environment.

The Federal Bureau of Sport Fisheries and Wildlife has completed a comprehensive study [16] of the Cosumnes River Division for the maintenance and enhancement of the fishery and wildlife throughout the basin. The existing fishery resource consists of Chinook salmon, rainbow and brown trout, striped bass, American shad and numerous warm-water species. In addition, a new fishery composed of steel head trout and Kokanee salmon will be developed under the project. Under the proposed plan, the fishery in the running water of the river and the stored water of the reservoirs will be maintained and enhanced. From historical records, the Cosumnes River is shown to have low flows and frequent dry periods. Therefore, the Federal Bureau of Sport Fisheries and Wildlife has proposed minimum flows and schedules for releases from project reservoirs for the maintenance of the fishery. These flows and schedules are shown on Table 11.

TABLE 11
FLOW SCHEDULE FOR FISH REQUIREMENTS
COSUMNES RIVER BASIN a/

Below Dam	Period	Rate of Flow (cfs)	<u>b/</u> : Flow :(acre-feet/year)
Nashville to Regulating Reservoir	Constant	20	14,400
Nashville Regulating Reservoir	Jan. 1-Apr. 1	200	126,700
	Apr. 1-Oct. 1	100	
	Oct. 1-Nov. 1	300	
	Nov. 1-Jan. 1	300	
Capps Crossing	Constant	5	3,600
Pi Pi	Jan. 1-Oct. 1	20	13,500
	Oct. 1-Jan. 1	15	
Aukum	Jan. 1-Oct. 1	20	13,500
Irish Hill		None	None

a/ Source: Bureau of Sport Fisheries and Wildlife [16].

b/ During drought years, flows will be diminished, as determined by the Bureau of Reclamation.

The Sacramento County Planning Commission has declared the Cosumnes River, including a green belt, to be preserved as a much needed recreational area. The protection of the recreation and aesthetic environment of the river would be considered an important water quality objective.

The Central Valley Regional Water Quality Control Board has established requirements for wastes discharged into the Cosumnes River and tributaries thereto. These requirements were established for various municipal and industrial discharges and were for the purpose of maintaining the surface and ground water for existing beneficial uses. A comprehensive water quality control policy for the entire basin will be developed in the near future by the Regional Board and more specific requirements will be available at that time. For the purposes of this study, criteria will be selected which will reflect the existing and planned beneficial uses of the river.

For the protection of the fishery, the dissolved oxygen levels shown on Table 12 are required for the running waters of the Cosumnes.

TABLE 12

REQUIRED DISSOLVED OXYGEN
COSUMNES RIVER BASIN

Warm Water Fishery	5.0 mg/liter
Migration of Anadromous Fishery	6.0 mg/liter
Cold Water Fishery	7.0 mg/liter
Spawning Area - Salmonids	9.0 mg/liter

Salmon spawning grounds, downstream from the Nashville Regulating Reservoir to about River Mile 5.0 on the main stem of the Cosumnes, will be maintained. Therefore, during the salmon spawning season (October to December) the level of dissolved oxygen should be maintained at 9.0 mg/liter to provide optimum environment for spawning. For the remainder of the year, the lower levels indicated in Table 12 are acceptable.

Water temperature of 55° Fahrenheit is required during the salmon spawning season in this stretch of the river, but naturally higher temperatures are acceptable for the remainder of the year and at other sections of the river and reservoirs.

To maintain optimum striped bass spawning conditions during the spring, a total dissolved solids (TDS) limit of 180 mg/liter has been adapted for the estuary reach of the Cosumnes (up to River Mile 5.0). This TDS level is recommended as the result of studies conducted by the California Department of Fish and Game [17] in the Sacramento-San Joaquin Delta.

For the enhancement of recreation and aesthetic enjoyment, the water of the Cosumnes should be essentially free from rooted aquatic plants, slimes, and high concentrations of algae and plankton. For the control of algae, slimes, and aquatic growths, criteria for total nitrogen and phosphorus are presented in Table 13.

TABLE 13

PROPOSED NITROGEN AND PHOSPHORUS CRITERIA
COSUMNES RIVER BASIN

Total Nitrogen (as N)	1.0 mg/liter
Total Phosphorus (as P)	0.1 mg/liter

The significance of nitrogen and phosphorus in receiving waters relates to undesirable growths of algal and aquatic weeds and severe dissolved oxygen depletions. As nutrient concentrations increase, the concentration of algal cells and aquatic growths will also increase. The limits shown on Table 13 are based on studies conducted by the Federal Water Pollution Control Administration in the Potomac River and the San Francisco Bay and Delta [15,18]. It is recognized that algal and aquatic growths could be sustained in water with lower nutrient levels than indicated above but the extent of growth would not normally reach nuisance proportion.

WATER QUALITY CONTROL FLOW REGULATION NEEDS

The required flow rates and total annual amounts of water needed to maintain minimum dissolved oxygen at various reaches of the Cosumnes River in the Middle and Lower Basins are presented in Table 14. The indicated flow regulation include deductions for domestic and industrial waste returns but does not include irrigation return water to the river.

Flow regulation required to dilute nitrogen and phosphorus loads to the specified limits are shown in Table 15. Present (1965) operation of sewage facilities will provide almost 50 percent removal of nitrogen and about 30 percent of phosphorus [14] and these removal efficiencies were used for computing municipal nutrient loads from these conventional treatment plants. To dilute the nutrient loads from these conventional treatment plants to desirable limits, the required flow regulation would exceed the total yield of the entire project before the year 2000 (see Table 15).

TABLE 14

FLOW REGULATION NEEDS FOR DISSOLVED OXYGEN CONTROL
COSUMNES RIVER BASIN ^{a/}

Stream Location	1970		2000		2020	
	Normal Spawning CFS	CFS	Normal Spawning CFS	CFS	Normal Spawning CFS	CFS
River Mile 27.5 - 5.0	2	6	5	17	7.5	26
River Mile 5.0 - 0	5	5	16	16	25	25

a/ Normal Flow; January to September

Salmon Spawning; October to December, Between River Mile 5 to 55

Flows include deductions for domestic and industrial waste returns but not for irrigation return to the river.

b/ River Mile 55 near Nashville Regulator Dam

River Mile 27.5 near Sloughhouse, California

River Mile 5.0 near Galt, California

River Mile 0. Confluence of Cosumnes and Mokelumne Rivers

TABLE 15

FLOW REQUIRED FOR NUTRIENT DILUTION
COSUMNES RIVER BASIN

Treatment Method		a/ Nitrogen			a/ Phosphorus		
		1970	2000	2020	1970	2000	2020
<u>Conventional Treatment</u> , ^{b/} cfs		52	135	242	187	485	812
1000 Acre-feet/year		38	98	175	135	350	586
<u>Advanced Treatment</u> , ^{c/} cfs		52	77	86	100	62	100
1000 Acre-feet/year		38	55	62	72	45	72

a/ First year after completion of first dam of the initial phase

b/ 50% Nitrogen and 30% Phosphorus Removal in Secondary Treatment

c/ 1970: Nitrogen Removal 50% in Secondary Treatment
Phosphorus Removal 60% in Advanced Treatment

2000: Nitrogen Removal 70% in Advanced Treatment
Phosphorus Removal 90% in Advanced Treatment

2020: Nitrogen Removal 80% in Advanced Treatment
Phosphorus Removal 90% in Advanced Treatment

Alternative methods should be considered for controlling nutrients in the river to specified limits. Removal efficiency of phosphorus from domestic waste could be increased up to 90 percent, by alteration of operational methods of standard activated sludge plants [19,20] or by employing advanced waste treatment methods [21,22,23]. For the purpose of this report, phosphorus removal up to 90 percent of influent municipal waste was used to compute revised flow regulation and the flows depending on advanced treatment techniques are shown on Table 15. Similarly, increased nitrogen removal efficiencies in domestic waste plants using advanced treatment methods of proven technical feasibility [21,22,23,24] could be utilized. Nitrogen removal rates up to 70 and 80 percent were used in computing the revised flow regulation needed by the year 2000 to 2020, respectively, and the revised dilution flows are shown on Table 15 for advanced treatment.

Treatment cost for nutrient removal was estimated to be about fifty (50) dollars per million gallon. This is net cost as deductions were allowed for the value of reclaimed water. This cost reflects current pilot plant and research and development studies [21,23,24] and includes capital investment, maintenance and operational costs for the advance treatment stage. By the year 2000, an annual cost of about \$109,000 would be incurred by municipalities for nutrient control, and this would rise to about \$211,000 by the year 2020.

A second alternative to the nutrient problem of the basin would envisage the collection of domestic and industrial wastes into a master sewer for disposal into the Sacramento-San Joaquin Delta or the Pacific Ocean. This alternative would limit nutrients into the Cosumnes River but would transfer the problem to the Delta or the Pacific Ocean. Water quality problems in the Delta will be critical in the near future and the unloading of inland nutrients here may not be a permanent solution to the basin's problems. Disposal to the Pacific Ocean is feasible but for the purpose of this study would not be considered in detail, as an ocean outfall system serving the entire San Francisco Bay-Delta complex must await further study. The Corps of Engineers is presently studying waste disposal problems in the Bay-Delta Complex but at this time, firm data are not available to permit a valid evaluation. Thus, any plan for diversion of waste out of the basin should not be considered for the purpose of this study, but it is recognized as a possible alternative, pending studies presently under progress by Federal and State agencies.

The disposal of agricultural sub-surface waste to the Delta or the Pacific Ocean from a master drain serving the San Joaquin Valley has been suggested by the Bureau of Reclamation and the State Department of Water Resources. It has been determined that this waste must be treated prior to discharge [15] to the Delta. The means of treatment is currently under study by the California Water Quality Control Board, California Department of Water Resources, Federal Bureau of Reclamation, Office of Saline Water, and the Federal Water Pollution Control Administration. These studies are in progress and conclusions are not expected in the immediate future. Therefore, for the purpose of this study on the Cosumnes River, the removal of nutrients from surface and sub-surface irrigation return flows would not be considered but this is a possible consideration for reduction of nutrients to the Delta.

Flow regulations necessary to maintain TDS standards in the estuary portion of the Lower Basin is shown on Table 16.

TABLE 16

FLOW REQUIRED FOR T.D.S. CONTROL
COSUMNES RIVER BASIN

	:	1970	:	2000	:	2020
Flow Required, ^{a/} cfs	:	0	:	45	:	60

a/ Flow required during bass spawning season, April and May in Cosumnes River Estuary (River Mile 0 - 5.0).

A review of the flows on the main stem of the Cosumnes River as recommended by the Bureau of Sport Fisheries and Wildlife (see Table 11) indicates that these flows are in excess of requirements for flow regulation for dissolved oxygen and dissolved solids. However, these flows will be adequate only for a few years after the completion of the initial phase for nutrient control under present waste treatment practices. After this period, flow regulations for nutrient dilution would exceed the recommended flows for the maintenance of the fishery, and furthermore would rapidly exceed the total yield of the entire initial and ultimate phase of the Cosumnes River Division Project by the year 2000. By the year 2020, dilution requirement would exceed the mean annual runoff of the basin. However, higher nitrogen and phosphorus removal rate by advanced sewage treatment facilities should be employed so that flow regulation requirement would not defeat the purpose of the project itself, by requiring flows greater than the project yield for dilution purposes. The requirement for municipalities to consider advanced treatment by the year 2000 is a practical and feasible solution for the maintenance of water quality standards.

Based on advanced treatment measures, it is concluded that storage for flow regulation on the main stem of the Cosumnes River for quality control will not be required, as the releases for maintenance of fishery would be in excess of the quality control requirements.

The Federal Bureau of Sport Fisheries and Wildlife [16] have concluded that it would be infeasible to develop a fishery in Laguna Creek, Dry Creek and Deer Creek. These are ephemeral streams with essentially no flows during a large part of the year. It is possible that some irrigation return water under ultimate development plans could reach these creeks, but the flows would not be dependable for fishery development purposes. Based on these conclusions, flow regulation for water quality control purposes will not be needed on these ephemeral streams.

From discussions with representatives of the Central Valley Regional Water Quality Control Board, the disposal of sewage effluent in the Upper Basin would be by land application and sub-surface percolation. Direct discharge to surface water would be prohibited for future developments. The hot and dry climate of the area would make surface application a suitable means of disposal of effluent from the larger crossroad community, but the smaller crossroads communities and isolated rural units will continue to use septic tanks and leaching fields for disposal of domestic wastes. The total population of the Upper Basin would be widely dispersed over a large area of the Sierra Nevada. Thus, it is anticipated that only little if any liquid wastes will reach running water. Furthermore, the Bureau of Sport Fisheries and Wildlife has specified minimum flows below the proposed dams in the Upper Basin (see Table 11). With these releases, it is concluded that flow regulation for water quality control will not be needed in the Upper Basin.

IX. OTHER EFFECTS OF PROJECT ON WATER QUALITY

EFFECTS ON SACRAMENTO-SAN JOAQUIN DELTA

Evaluation of the impact of the project upon water quality must consider not only the effects within the local service area but also the more widespread external effects of the project. Within the study area, degradation of the mineral quality is anticipated from impoundment and from the consumptive use of project water. Deterioration would result from natural evaporation of stored and applied irrigation water and from the solution of salts during domestic and industrial use. Thus, increases in TDS and specific minerals can be expected in both surface and ground water drainage from the study basins; however, within the study area, the degradation is not expected to create any problems.

The more widespread effects of the project on the beneficial uses of water in the Central Valley and the Sacramento-San Joaquin Delta, (see Figure 1) system should be considered. Preservation of water quality in the Delta is dependent upon adequate treatment of municipal and industrial wastes prior to discharge and the maintenance of adequate streamflow to provide conveyance of residual conservative and non-conservation waste to ultimate disposal in the Pacific Ocean. Dilution or conveyance water is particularly important in the disposal of drainage from irrigated agricultural land, since adequate treatment systems usually are not feasible. Maintenance of acceptable water quality must be considered in the development of water supplies for irrigated agriculture since the resulting diminution of flow and production of concentrated return flows could have significant adverse effects in the basin.

The yield of the Central Valley Project would be increased by 155,000 acre-feet annually as a result of this project. At present, this 155,000 acre-feet constitute a part of the annual Sacramento-San Joaquin Delta outflow. Under the ultimate plan of development this annual outflow will be reduced by a quantity slightly less than this 155,000 acre-feet (allow for irrigation efficiency). This reduction could result in some degradation of water quality in the Delta.

Water quality standards are presently being prepared in compliance with the Federal Water Quality Act of 1965 (PL 89-234).

It is most probable that the maintenance of these standards will be dependent in part upon the maintenance of an adequate outflow from the Delta for the purpose of conveying conservative wastes out of the Sacramento - San Joaquin River basins and for repelling the incursion of sea water. The maintenance of this Delta outflow during the critical summer months is dependent upon the integrated operation of all units of the Bureau of Reclamation's Central Valley Project (CVP) and the State Water Plan.

Because the Cosumnes River Division is only one of many units of the CVP and since the operation of the CVP is complex, it is not possible to relate the required Delta outflow in a direct manner to the 155,000 acre-feet annual yield to be developed by the Cosumnes Unit. Although the degradation resulting from consumptive use of the water developed in the Cosumnes River Division may be small and not identifiable in the Delta, the operation of the entire CVP, including all existing and future units, should recognize and avoid depletion of Delta outflow below that which will be necessary to maintain a water quality at least equal to the standards which will be established by the State and Federal Governments.

EFFECTS OF STORAGE IMPOUNDMENT

The quality of water stored in an artificial impoundment may vary greatly from the quality of the inflow. The quality variations can be either beneficial or detrimental to the water user. Beneficial effects, such as a reduction in turbidity and dilution of inflow to give a fairly constant quality, facilitate water treatment operations. Detrimental quality changes which may occur are: 1) increased growth of plankton; 2) temperature stratification of the reservoir resulting in a zone of lowered oxygen concentration in the lower depths or hypolimnion; and 3) increases in the dissolved mineral concentration.

If the impoundment is to be used as a source of domestic and industrial water supply, the detrimental quality changes can lower the economic value of the supply. One type of algae, the blue-green, has been implicated as a major cause of taste and odor problems. Other plankton forms (both algae and diatoms) cause difficulty in water treatment plants by clogging the filters. Thermal stratification becomes a problem because of the resistance of a thermally stratified reservoir to mixing. The more dense hypolimnion serves as a repository for all of the settleable organic and inorganic material. The decaying organic material depletes the oxygen resources and may cause tastes, odors, and unsightly discoloration. In addition, if the reservoir is subject to seasonal overturns, the result may be a prolific plankton bloom stimulated by the large quantities of nutrient material cycled from the lower depths. Problems of thermal

stratification can often be minimized or overcome through the provision of reservoir outlets at several depths or artificial mixing.

The third detrimental effect, the increase in dissolved minerals and hardness is not only the result of natural evaporation but also the bacterial activity and is dependent on the chemical characteristics of the water and the geo-chemistry of the inundated land.

Water quality can be a definite constraint on the usefulness of water stored in an impoundment. A poor quality water requiring a high degree of treatment is expensive for the consumer. Consequently, the water quality aspects should be considered during the planning stage of any reservoir intended to serve as a source for municipal and/or industrial water supply.

Observations of water quality at Pardee Reservoir, Camanche Reservoir and Folsom Lake in adjoining watersheds show that stratification is common from late spring to fall, followed by a seasonal turnover in the late fall. It could be predicted that stratification would be experienced also in the new reservoirs. Unless outlet works are properly constructed, this could result in the discharge of water deficient in oxygen from the bottom of reservoirs, water with high iron and manganese content, unfavorable pH and temperatures, and high turbidity. The fishery on the main stem of the Cosumnes River below Nashville Reservoir could be adversely affected. There is a requirement to maintain water at 55° Fahrenheit in the spawning ground below Nashville Dam during the salmon spawning season. It is, therefore, recommended that a multi-level outlet structure be provided at Nashville Dam to permit the withdrawal of the best quality water available at time of release.

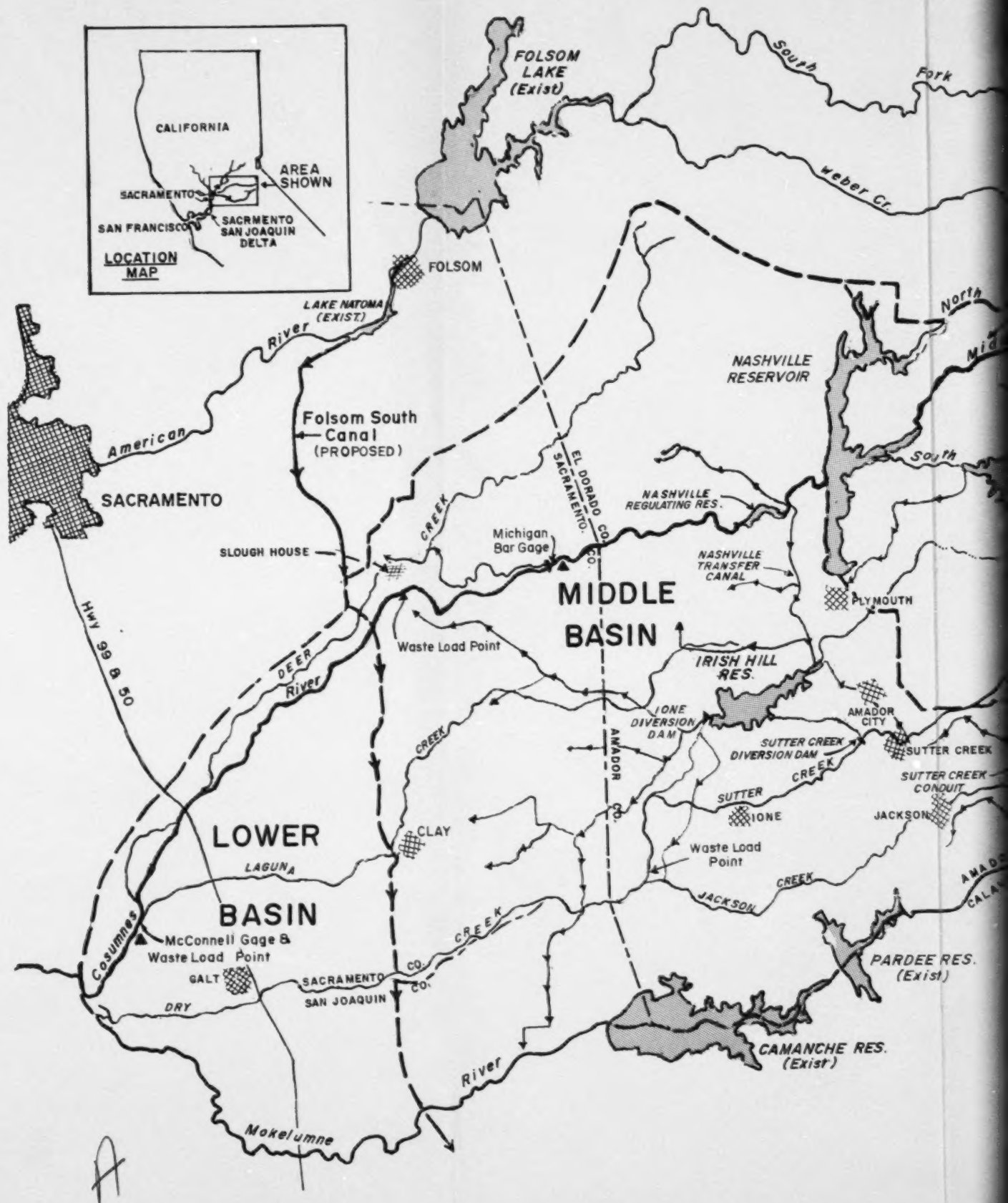
EFFECTS OF PROJECT CONSTRUCTION

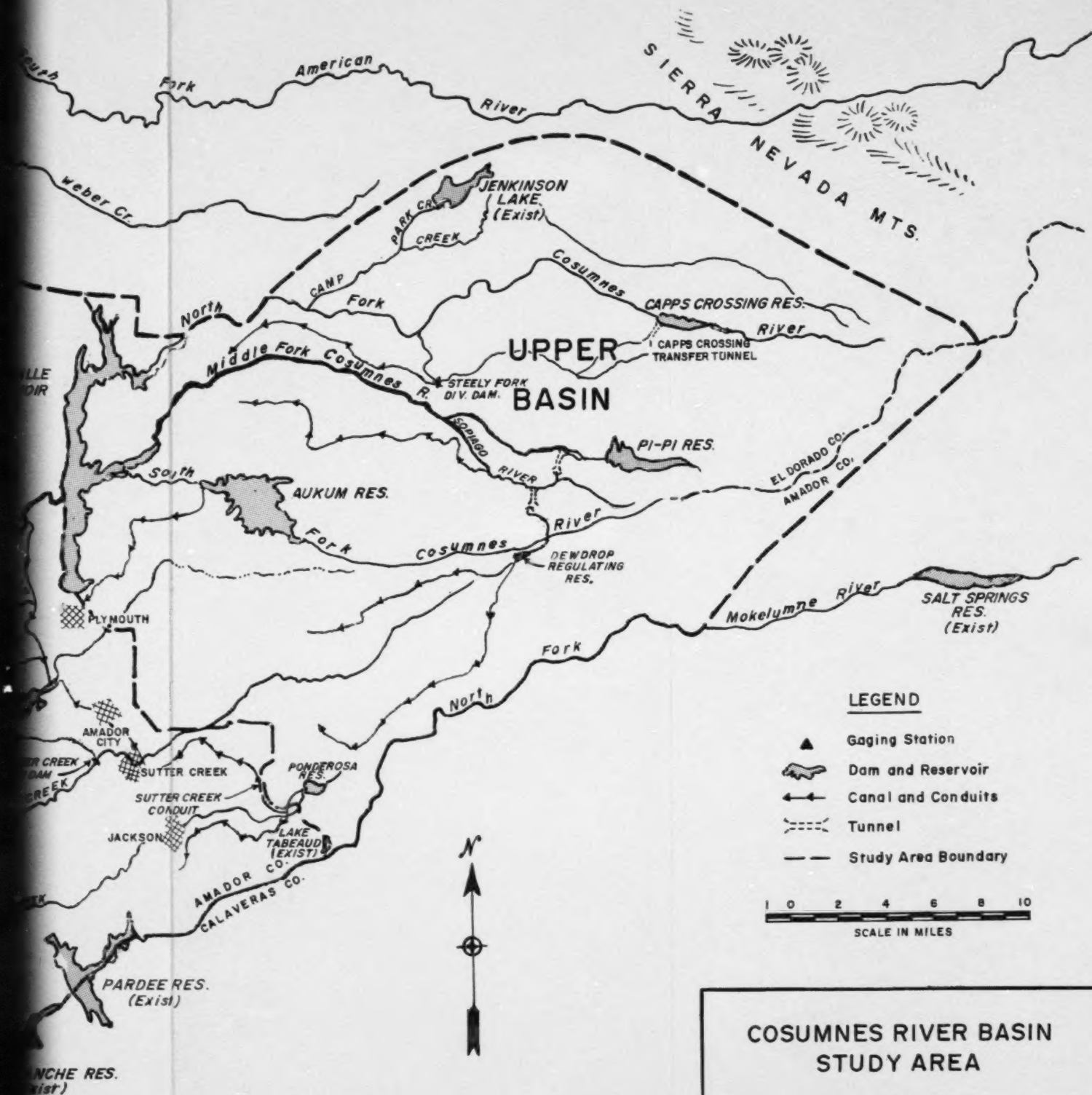
During the construction of the project, adequate measures must be taken to protect both surface and ground waters. Provisions should be included in contract specifications so contractors would be cognizant of requirements to protect water quality in the work area. Silt detention basins should be constructed at all work areas to eliminate excessive turbidity leaching from earth work to the streams. In equipment maintenance areas, special precautions should be taken to contain spilled fuel, lubrication products and wash water. Sewage from construction camps should be contained on land. All construction activities affecting water quality should comply with requirements of State Water Quality Control and State/Local Public Health authorities. Comments from the Federal Water Pollution Control Administration should be requested by the construction agency during the preparation of project plans and specifications in compliance with Executive Order 11288.

X. BIBLIOGRAPHY

1. U. S. GEOLOGICAL SURVEY, DEPARTMENT OF THE INTERIOR. Compilation of Records of Surface Waters of the United States, Pacific Slope Basins through 1950 and 1950-1960, WSP 1315A (1959) and WSP 1735 (1966). Government Printing Office.
2. U. S. GEOLOGICAL SURVEY, DEPARTMENT OF THE INTERIOR. Flow Duration and High and Low Flow Tables for California Streams, Government Printing Office 1961.
3. U. S. BUREAU OF RECLAMATION, DEPARTMENT OF THE INTERIOR. Cosumnes River Division, Central Valley Project, Hydrology Appendix, Region 2, Sacramento, California, November 1963.
4. CALIFORNIA DEPARTMENT OF WATER RESOURCES. Bulletin No. 65, Quality of Surface Waters in California, 1958-1961.
5. U. S. GEOLOGICAL SURVEY, DEPARTMENT OF THE INTERIOR. Temperature of Surface Waters in Conterminous United States, Hydrologic Investigations ATLAS HA-235, Government Printing Office, 1966.
6. U. S. GEOLOGICAL SURVEY, DEPARTMENT OF THE INTERIOR. Quality of Surface Waters of the United States, WSP 1951, Government Printing Office, 1966.
7. CALIFORNIA DEPARTMENT OF WATER RESOURCES. Bulletin No. 66, Quality of Ground Water in California, 1957-1962.
8. U. S. BUREAU OF THE CENSUS, DEPARTMENT OF COMMERCE. Census of Agriculture, Government Printing Office, 1959.
9. U. S. NATIONAL PARK SERVICE, DEPARTMENT OF THE INTERIOR. Project Report on the Recreation Potentialities of the Cosumnes River Division, Central Valley Project, California, September 1964.
10. U. S. BUREAU OF THE CENSUS, DEPARTMENT OF COMMERCE. Census of Population, 1960, Government Printing Office, 1963.
11. U. S. BUREAU OF RECLAMATION, DEPARTMENT OF THE INTERIOR. Office Records, 1967.
12. U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE, PUBLIC HEALTH SERVICE. Inventory of Municipal Waste Facilities, 1962, Government Printing Office, 1963.
13. CENTRAL VALLEY WATER QUALITY CONTROL BOARD. Office Records, Sacramento, California, 1967.

14. WEINBERGER, L. W., D. G. STEPHAN AND F. M. MIDDLETON, Solving Our Water Problems - Water Renovation and Reuse, New York Academy of Science, 1966.
15. FEDERAL WATER POLLUTION CONTROL ADMINISTRATION, DEPARTMENT OF THE INTERIOR. San Joaquin Master Drain, Effects on Water Quality of San Francisco Bay and Delta, 1967.
16. U. S. FISH AND WILDLIFE SERVICE, DEPARTMENT OF THE INTERIOR. A Detailed Report on Fish and Wildlife Resources Affected by the Cosumnes River Division, Initial Phase, Central Valley Project, California, September, 1963.
17. TURNER, J. L. AND D. W. KELLEY, Ecological Studies of the Sacramento-San Joaquin Delta Part II Fishes of the Delta, Fish Bulletin 136, California Department of Fish and Game, 1966.
18. FEDERAL WATER POLLUTION CONTROL ADMINISTRATION, DEPARTMENT OF THE INTERIOR. Interdepartmental Task Force on Project Potomac, Sub-Task Force on Water Quality, February, 1967.
19. VACKER, D., C. H. CONNELL, AND W. N. WELLS, Phosphate Removal Through Municipal Wastewater Treatment at San Antonio, Texas, Jo. Water Pollution Control Federation, Vol. 39, (May 1967).
20. LEVEN, G. V. AND J. SHAPIRO. Metabolic Uptake of Phosphorus by Wastewater Organisms. Jo. Water Pollution Control Federation, Vol. 37, 6 (June 1965).
21. ELIASSEN, R. AND G. E. BENNETT. Anion Exchange and Filtration Techniques for Wastewater Renovation. Jo. Water Pollution Control Federation, Vol. 39, IOR (Oct. 1967).
22. SAWYER, C. N. AND J. C. BUZZELL. Removal of Algal Nutrient from Raw Wastewater with Lime. Jo. Water Pollution Control Federation, Vol. 39, IOR (Oct. 1967).
23. BRUNNER, C. A. Pilot Plant Experiences in Demineralization of Secondary Effluent Using Electrodialysis. Jo. Water Pollution Control Federation, Vol. 39, IOR (Oct. 1967).
24. CULP, G., Nitrogen Removal from Sewage, Report for South Tahoe Public Utility District, February, 1966.





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